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PASSING THROUGH SOME CONVERSION SYSTEMS

by

K. Eckes

FTD ID(RS)I-0389-77

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EDITED TRANSLATION

FTD-ID(RS)I-0389-77 5 April 1977

FTD-77-C-000319

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English pages: 11

Source: Geodezja i Kartografia, Vol 25, NR 3, 1976, PP. 169-175.

Country of origin: Poland
Translated by: LINGUISTICS SYSTEMS, INC
F33657-76-D-0389
Walter Whelan
Requester: FTD/PDBA
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STUDIES OF GEODETIC INFORMATION FLOW CONTENT PASSING THRU SOME CONVERSION SYSTEMS

Konrad Eckes

I. Introduction

In studies on the structure of existing information systems as also in the planning of new technological solutions, in which we exploit the methods of systems analysis /8/ there occurs a need to determine losses of information in conversion systems or, as the case may be, in planning jobs--a need for coupling channels of such thruput capacities as to produce optimal conditions of information flow.

Making use of a diagnostic method in the planning of a geodetic information system, as basic starting material we accept the results of traditional technological analysis. The carrying out of such an analysis is associated with the need for the acceptance of a definite model of the flow of information in the system as well as the determination of the magnitudes of this flow on the basis of a proposed measure.

In the reference work /4/ there was built a communication model of a geodetic information system--which resulted from its communication structure. The communication ~~system~~ structure for acting in the system is typical for the majority of processes; the system extracts information, converts it and presents it at the output and thus in the technological lines of the system there follows a flow of information in time and space. After accepting such a structure there appeals additionally a need for a wide use, in the information system, of modern

telecommunication means in order to significantly diminish the reaction time of some technological lines of the system.

2. The Concept of the Flow of Geodetic Information

The technology of a geodetic information system is characterized by by the great variety of the forms of the elementary messages: These messages are presented analytically as well as in graphical form at various scales, in accordance with various algorithms for PROJECTION copying. For the above mentionned elementary messages of the system, ~~we must~~ we must accept a common base of reference--a uniform point of view on every type of information in the system.

As a common base of reference for elementary messages of the the system there was proposed in the reference work /4/ the flow of geodetic information.

The flow of geodetic information is then a function determined on the set X--of the outputs of the determinate measurement channel, or of a CONCATENATION cascade of channels of the system and which (function) accepts values in the set of elementary messages A. The elements of the set X are natural numbers which constitute terms of an arithmetic sequence, in which the difference r is the smallest distinguishable interval of the output of a determinate measurement channel or of a CONCATENATION cascade of channels of the system.

From the flow of information we can separate out a finite sequence of elementary messages.

$$S = (s_1 , s_2 , \ldots , s_q) \quad (1)$$

which is a function of arguments (of the outputs of the determinate measurement channel or of a CONCATENATION ~~cascade~~ of channels), contained in the interval E, called a unit of measurement. Such a sequence we will call a <u>unit flow</u>.

3. <u>Entropy of a unit source as information flow content</u>

The acceptance of the communication structure of the system, the creation of a common base of reference in the form of information flow, as well as the separating out from it of a unit flow, constitutes a consistent realization of a set of conditions for the use of a precise method of investigation--information theory ((the mathematical theory of telecommunication) of C. E, Shannon.

Let us now create a source of messages /1/ from the unit flow by providing ? for the elementary messages the probabilities:

$$P(s_1), P(s_2), \ldots, P(s_q) \qquad (2)$$

with which they are selected. The above source we will be calling a <u>unit source</u>.

For simplification we assume that the probabilities (2) are equal to each other,

$$P(s_1) = P(s_2) = \ldots, P(s_q) = \frac{1}{2} \qquad (3)$$

as well as that the unitary source created is a source without memory, that is the elementary messages are statistically independent. The acceptance of the above assumptions can evoke certain RESTRICTIONS ~~conditions~~ /4/ since the sources of the geodetic system are characterized by a low level of organization, however such assumptions, unimportant for the examination of the problem, significantly simplify the CONSIDERATIONS ~~arguments~~.

Let us compute now the average amount of information ~~falling~~ occurring in to an elementary message that is supplied by the source created. The entropy /1/ of a source without memory is given by the expression:

$$H(S) = \sum_{S} P(s_i) \log_2 \frac{1}{P(s_i)} \quad \text{bits} \qquad (4)$$

which in view of the simplifying assumptions (3) assumes the form:

$$H(S) = \log_2 q \quad \text{bits} \qquad (5)$$

It is neccessary to stress that the value of the entropy presented with the help of ~~equation~~ expression (5) is identical with the value deduced in the (reference) work /4/ of the maximal transinformation (no noise) of the deterministic input channel in the information measurement systems of the overall system.

The entropy of the unit source created from the flow of information, presented with the help of the expression (5) we will call the <u>flow content (capacity)</u>.

Since we can also treat an outlet channel of a [4] conversion system as a flow of information, thus we will also be using the equivalent term <u>capacity of an information channel</u> . The suggested agreed-upon measure of the thruput capacity makes possible the characterization of a broad range of information flows and channels of the geodetic information system.

Making use of the above proposed measure of capacity (content) and establishing the agreed upon unit of measure E (as) equal to 1 meter for all of our ~~arguments~~ considerations, we will characterize the information content (capacity) of several flows entering the system /4/ or appearing at the output of numerical-to-graphic (dig-analog) conversion system/4,16/

	Strumień lub kanał systemu A	Ilość wyjść źródła jednostkowego (liczność podzbioru wiadomości elementarnych $\{s_i\}$) B	Entropia źródła jednostkowego (pojemność strumienia informacji lub pojemność informacyjna kanału) [bitów] C
D	Strumień wiadomości na wyjściu pomiaru liniowego dalmierzem redukcyjnym jednoobrazowym; rozróżnialny interwał kanału deterministycznego wyjścia — 0,1 m	10	3,322
E	Strumień wiadomości na wyjściu pomiaru liniowego taśmą; rozróżnialny interwał kanału deterministycznego wyjścia — 0,01 m	100	6,644
F	Strumień wiadomości na wyjściu pomiaru niwelacyjnego (niwelacja techniczna); rozróżnialny interwał kanału deterministycznego wyjścia — 0,001 m	1 000	9,966
G	Kanał wyjścia układu przetwarzania cyfrowograficznego metodą tradycyjną; rozróżnialny interwał operacyjny — 0,1 mm	10 000	13,288
H	Kanał wyjścia układu przetwarzania cyfrowograficznego przy wykorzystaniu plotterów sterowanych numerycznie; parametry typowe dla plotterów średniej i wysokiej dokładności: — dokładność wyjściowa — 0,05 mm — dokładność wyjściowa — 0,02 mm	 20 000 50 000	 14,288 15,610

table I

Table I (callouts) A— Flow or channel of the overall system B—Number of outlets (outputs) of a unit source ((size of the subset of elementary messages $\{s_i\}$) C— Entropy of a unit source ((content of the information flow or information capacity of the channel) /bits/.

D— Flow of messages at an outlet with linear measurement by a reducing single-image telemeter device; distinguishable interval of the deterministic output channel --0.1 m

E— Flow of messages at an outlet with linear measurement by tape; distinguishable interval of the deterministic output channel --0.01 meters

F-- Flow of messages at an outlet with leveling measure ((technical leveling); distiguishable interval of the deterministic output channel -- 0.001 meters.

G-- Output channel of a subsystem for numerical-to-graphic conversion by the traditional method; distiguishable operating interval 0.1 mm

H-- Output channel of a numerical-to-graphical conversion subsystem with exploitation of numerically controlled plotters; typical parameters for plotters of average and high accuracy:

--output accuracy --0.05 mm

--output accuracy --0.02 mm

Such a characteristic is presented on table #1.

4. Equation of Information Flow Passing thru a Converter

Taking into account the fact that a numerical-to-graphic conversion is typical and one of the basic processes of the system under discussion, we will deduce theoretical considerations, for instance, of an information system during passage thru a numerical-to-graphic conversion subsystem.

At the output of this subsystem we obtain an isomorphic model of the terrain--a map. It is obvious that one of the important conditions in creating the model, in order to simplify the carrying out of operations on it, is its diminution in relation to the original. The diminution determined by the scale of the map 1:M is one of the basic functions of the discussed conversion subsystem. Then the flow of information which appears at the input is subjected to a COMPACTION ~~densification~~ of value $\log_2 M$, as a consequence of which the information flow content (capacity) in the converter is equal to the sum of the original content (capacity) and of the binary log $(\log_2 M)$ of the denominator of the scale of conversion.

This flow appears in turn at the output of the converter thru a channel of information capacity determined by the construction of the converter. If we assume that noise does not accompany the operation of the system /1/, /2/, then we can describe the work of the converter with the help of the equation proposed in (reference) work /4/:

$$H(S)_p + \log_2 M = H(S)_w - \Delta H \quad , \tag{6}$$

where $H(S)_p$--is the information flow content (capacity) at the input of the converter; M--is the denominator of tha scale of conversion; $H(S)_w$ --is the information capacity of the output channel of the converter,

ΔH--is the average loss of information ((or incompletedness, unfilledness) falling to (occurring at) the elementary output of the conversion system.

The relation (6) we will be calling the <u>equation of information flow passing thru the converter</u>. From this equation we can determine the losses of information in numerical-to-graphic conversion processes and of transmitting (forwarding) in accordance with the simple transformation:

$$\Delta H = H(S)_w - (H(S)_p + \log_2 M) \qquad (7)$$

5. A study of some conversion subsystems of the system

Now we shall pass on to experimental studies on changes of the information flow content (capacity) in a process of numerical-to-graphical conversion. The computations we perform on numerical values scooped up from the instruction-in-force /9/, that has to do with measurements of location for data of the requirements for accuracy of Group I of terrain details ((page #38, table #VII). Besides the typical scales shown in instruction /9/, in the computations there has been taken into consideration also the currently used scale of a basic map--1:500. The information capacity of the output channel of the converter was determined on the basis of the distinguishable operating interval in the converter by the traditional method ((table #1). The computations have been carried out in table #2. For simplification the results of the computations, average losses of information occurring at an elementary outlet of the converting subsystem, were presented in the form of charts on diagram #1.

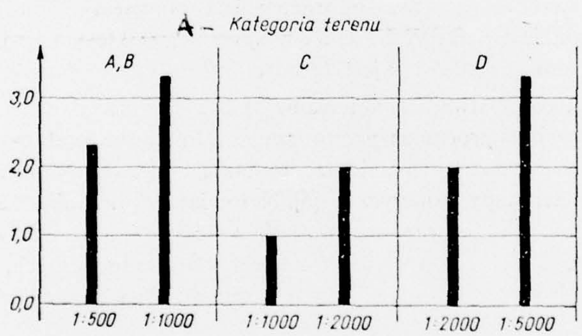
The magnitudes distinguished of losses of information were determined by the lack of correlation between the scales of the the basic

map provided in the instruction, the accuracies of readoff of distances in individual categories of terrain, as well as (among) the distinguishable operating interval of charting by the traditional method.

Tabela 2 table #2

A Kategoria terenu	A $H(S)_w$ [bitów] F	C Dokładność odczytu odległości	D Ilość wyjść źródła jednostkowego	$H(S)_p$ [bitów] F	1:*M*	$\log_2 M$	ΔH [bitów] F
A, B	13,288	0,01 m	100	6,644	1:500 1:1000	8,966 9,966	−2,322 −3,322
C	13,288	0,05 m	20	4,322	1:1000 1:2000	9,966 10,966	−1,000 −2,000
D	13,288	0,05 m	20	4,322	1:2000 1:5000	10,966 12,288	−2,000 −3,322

(callouts for Table #2) A:-- category of terrain F-- (symbol) in bits C:--accuracy of the read-off of distances D:--amount of outputs(lets) of the unit source.



Rys. 1. Średnie straty informacji (w bitach) przypadające na elementarne wyjście układu przetwarzania; obliczenia wykonano na podstawie wartości liczbowych z obowiązującej instrukcji C-I — Pomiary sytuacyjne

Diagram #1 Average losses of information (in bits) occurring at an elementary output of a converter subsystem; the computations were carried out on the basis of numerical values from the instruction-in-force C-I --measurements of location. A:--category of terrain

From the losses shown above we must not draw suggestions about the sui-

tability of diminution of the corresponding flow contents at the output of the (overall) system; these flows can not be subjected to losses in other converters of the (overall) system, for instance in analytic conversion.

We shall pass now to the computations of changes in the information flow content (capacity) in the process of sending thru graphical images of maps thru a telecommunication link. It is neccessary to suppose that in the information system this rapid means of transmitting of geodetic documents will be widely used. In our reasonings we take advantage of technical data of the telecommunication set-up, whose input and output operate on the basis of the development of a picture. We will carry out the computations for the data of the Rank Xerox 400 /10/, /11/ facsimile telecopier. This telecopier makes possible transmission of documents of the A-4 format thru a telephone link in the course of 4 minutes with a resolving power of 25.2 lines per cm, and --in the course of 6 minutes with a resolving power of 37.8 lines per cm. The cited resolving powers of the telecopier allow the obtaining at the output of 2520 and 3780 elementary messages in the assumed unit--1 meter. The information capacity of the output channel amounts then to 11.30 bits for quicker transmission and 11.88 for slower transmission. If we assume that we want to send thru a cartographic image of for instance 5 lines per mm resolving capability, then into the input of the subsystem under discussion we direct a flow of information of content 12.29 bits. Since the content (capacity) of this flow is greater than the information capacity of the ~~information~~ communication channels under discussion we must enter into the accounts an average information loss of 0.99 bits for the greater and 0.41 bits for the lesser speed of transmission of the telecopier on an analysis element of the image.

6. Summary

As the computations have shown in some of the cases under discussion of conversion, there arise rather large information losses. To the study of the losses of information it is neccessary to attach considerable weight (importance) since the scattering of information is an irreversible process. If the information is the result of our operation in the system behind which there is hidden a conversion of energy and materials, then it is obvious ~~then it is obvious~~ that the loss of information is a negative (undesirable) phenomenon.

An (overall) information system produces for us real opportunities to elimininate or significantly diminish losses of information in conversion processes. The removal of the losses can be realized in the case of the preservation (storage) and conversion of information, in analytic form, for instance in the form of a numerical map /6/. Moreover in the case of charting, losses can be significantly diminished by the use of automatic conversion with the help of plotters /3/, /5/, /6/, &/7/. And thus from among several economic advantages, also significant diminution of losses of information((See table #1) is a valuable advantage of an information system device.

The proposed measure of flow content as well as of the capacity of an information channel can be one of the tools in the study operations on the solution of some problems in the planning of information systems. It (THE MEASURE) can find application in correlation studies on flows and channels of a system in which there flow not-directly-comparable sequences of elementary messages and in varied forms they (MESSAGES) are suggested for processes of storage convesion and transmission.

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1. REPORT NUMBER FTD-ID(RS)I-0389-77	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) STUDIES OF GEODETIC INFORMATION FLOW CONTENT PASSING THROUGH SOME CONVERSION SYSTEMS		5. TYPE OF REPORT & PERIOD COVERED Translation
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) K. Eckes		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Foreign Technology Division Air Force Systems Command U. S. Air Force		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS		12. REPORT DATE 1976
		13. NUMBER OF PAGES 11
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

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